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RESEARCH ARTICLE

Evaluation of the design effects of different agropastoral systems on the diversity and density of spiders

Melina S. Almada[1], Alda González[2] and José A. Corronca[3]

[1]CONICET-EEA-INTA-Reconquista. Ruta 11 Km 773 (3560) Reconquista, Santa Fe. Argentina. [2] CEPAVE–CONICET, Facultad de Ciencias Naturales y Museo de La Plata (UNLP). Boulevard 120 s/n e/61 y 62, 1900, La Plata. Argentina. [3] CONICET-IEBI-UNSa, Av. Bolivia 5150, Salta. Argentina.

Abstract

Sustainable agro-ecological design is challenging when the goal is self-regulation of the system. The objective of this study was to evaluate if the agropastoral design system affects the spider community, as spiders are the main predators in these production systems, and to determine those designs which maximize the diversity and density of spiders. The study was conducted during 2009/2010, at the Experimental Research Station of Agriculture (EEA-INTA) Reconquista (Santa Fe, Argentina) where we considered four different designs: C1 (five agricultural fields), C2 (three agricultural fields and fourlivestock fields), C3 (six agricultural fields and one livestock field) and C4 (five agricultural fields and one forest area). In each design, the spiders were collected by pitfall traps and suction samples with a G-Vac (garden-vacuum). The designs proposed were considered on the basis of environmental heterogeneity. The C4 treatment had the greatest number of species, followed by C2, C3 and C1 (183, 178, 144 and 142 species, respectively), and C2 presented the greatest abundance of spiders followed by C4, C3 and C1 (n=5708, 4785, 4271 and 3448, respectively). Eight guilds were present in C3 and C4. This study is the first to evaluate the diversity of spiders in agropastoral systems in Argentina. Our results show that designs that include more fields with livestock orequal to those for agriculture, as well as forest areas, increase environmental heterogeneity. Therefore, the presence of a biological controller and dominant predatory group will be possible with sustainable designs that have environmental heterogeneity, contributing to improved pest control in agricultural systems.

Additional key words: araneofauna; agro-ecological design; biological control; environmental heterogeneity.

Abbreviations used: AEEA-INTA (Experimental Station of Agriculture-National Institute of Agricultural Technology); C1 (design with 5 agricultural fields); C2 (design with 3 agricultural fields and 4 livestock fields); C3 (design with 6 agricultural fields and 1 livestock field); C4 (design with 5 agricultural fields and 1 forest area).

Authors' contributions: Conceived and designed the experiments, and analyzed and interpreted data: MSA and JAC. Wrote the paper: MSA. Critical revision of the manuscript for important intellectual content: MSA, AG and JAC. Supervised the work: AG and JAC.

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Correspondence should be addressed to Melina S. Almada: almadamelina@gmail.com

Introduction

Spiders (Araneae) are common generalist predators in ecosystems and have an important role in the biological control of pest species, especially in crops (Meissle & Lang, 2005; Schmidt & Tscharntke, 2005). They have gained wide acceptance in biodiversity studies and conservation programs because they are good indicators of the environment based on changes in their diversity and are suitable for evaluating the impact of fragmented habitats (Clausen, 1986; Maelfait *et al.,* 1990; Uetz, 1991; Clark *et al.,* 2004; Tsai *et al.,* 2006; Cardoso *et al.,* 2011; Robertson *et al.,* 2011).

Some species of spiders increase their numbers within the crops that dominate the system, and these species are called agrobionts. Agrobionts are able to synchronize their development with the phenological development of the crop (Luczak, 1979; Samu & Szinetár, 2002). In contrast, in natural grasslands or systems where there is a greater availability of strata and niches, spiders do not dominate a particular environment but instead increase their richness of species, indicating a direct relationship between the structural complexity of habitat and species diversity (Uetz, 1979; Wise, 1993). In addition, spiders choose their environment in accordance with the own physical structure.

Generating sustainable agricultural designs within an agroecosystem is a huge challenge for agroecology. Thus, it is necessary to use different processes that impact the spatial and temporal diversification and strengthen it (Altieri, 1999). Among the sustainable designs, the silvopastoral one increases habitat diversity by incorporating trees and pastures, which improves the production conditions in areas destined for livestock. This favors the conservation of native flora and fauna, protection of water sources and soil rehabilitation (Guzmán *et al.,* 2010). These contributions improve the sustainability of production systems and constitute one of the main factors for the maintenance of species diversity and the control of undesirable organisms (Muriel & Vélez, 2004).

Plant architecture and landscape diversity have a direct influence on the composition of species assemblages within a habitat. This is due to the fact that structurally complex areas and sites offer more resources available for the maintenance and survival of most species (Isaia *et al.,* 2006). Thus, increasing the habitat heterogeneity of a simple agroecosystem by adding environmental diversity will impact the species richness and, therefore, the abundance of the natural enemies (Alderweireldt, 1994; Sunderland & Samu, 2000).

In recent years, the area destined for agricultural and livestock systems has increased in Argentina, reaching more than 35 million hectares (CES, 2012), with management practices and technologies joined permanently to optimize production. This situation impacts agroecosystems by reducing natural habitats, increasing disturbances, causing pest problems in crops and producing changes in species diversity (Verhoef & Morin, 2010). In this context, the design of production systems able to minimize pest emergence is important for integrated pest management (IPM) (Van Driesche *et al.,* 2007; Trumper, 2014). Strategies included are the manipulation of the productive system, the design of areas to increase fertility and longevity of natural enemies of insect pests (Straub & Snyder, 2006) and the maintenance of areas adjacent to the crop with natural vegetation as a refuge for spiders for hibernation and colonization (Liljesthrom *et al.,* 2002; Öberg & Ekbom, 2006).

In Argentina, there have been no empirical studies that evaluate the effect of agropastoral system designs on the natural enemies of insect pests. Therefore, the objective of this study was to evaluate whether the agropastoral system design affects the spider community, the principal predator group of these production systems, and to determine those designs which maximize the diversity and density of spiders, in order to assess if: (i) spatial designs of fields produce changes in the composition of spider assemblies; (ii) agropastoral systems which show greater environmental heterogeneity increase the diversity and density of spiders; and (iii) the number and composition of spider guilds (defined by how they capture their prey) is different in agropastoral systems compared to those that are purely agricultural.

Material and methods

Experimental area

This study was carried out at the Reconquista Experimental Station of Agriculture (EEA) INTA (National Institute of Agricultural Technology), (29°11´S - 59°52´O), Santa Fe, Argentina (Fig. 1). The region has specific phytogeograpic characteristics from the forests and wetlands from the humid Chaco. The annual average temperature exceeds 20 ºC with rainfall of about 1100 – 1200 mm per year (Pereyra, 2003).

The study included 21 fields: 15 agricultural fields with soybean crops (Fields No. 1, 3, 4, 6, 7, 8 and 19), cotton (13 and 15), sunflower (2, 18 and 20), wheat (16) and alfalfa (14 and 17), and five fields with livestock (5, 9, 10, 11 and 12). The livestock fields were characterized by wild grasslands with "yellow straw" *Sorghastrum setosum* (Griseb.) Hitchc. as the dominating species, accompanied by forage species: *Paspalum notatum* (Flüggé), *P. urvillei* (Steud), *Sporobolus indicus* ((L.) R.Br.), *Leersia hexandra* (Swartz) and an area of native forest (Field C) characterized by the following trees (including common names in Spanish): "chañar"

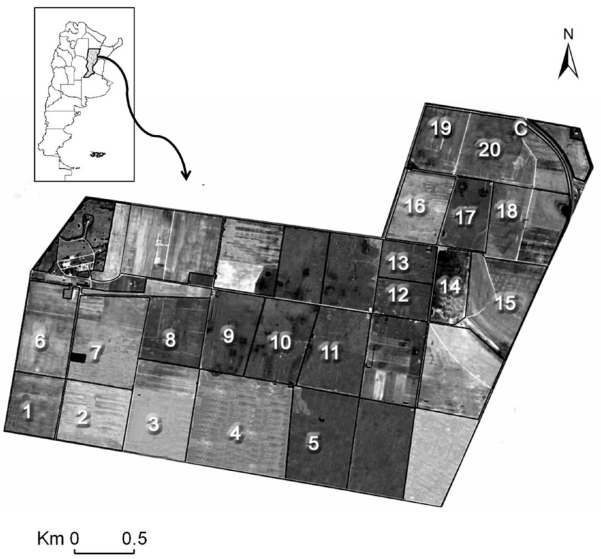

Figure 1. Studied fields of the EEA-INTA Reconquista, Santa Fe (Argentina). Fields with crops: 1, 2, 3, 4, 6, 7, 8, 13, 14, 15, 16, 17, 18, 19 and 20. Fields with livestock: 5, 9, 10, 11 and 12. C: Areas of control.

Table 1. Description of each case, corresponding to the number and type of crop per field, within agropastoral systems in the EEA-INTA Reconquista, Santa Fe (Argentina).

Cases	Amount and type of field	Central field number[1]	Field numbers surrounding[1]	Extension surfaces (ha)
C1	5 agricultural fields	2 (Sun)	1-3-6-7 (Soy)	210
C2	3 agricultural fields and 4 fields with livestock	4 (Soy)	3-8 (Soy) 5-9-10-11 (Ca)	290
C3	6 agricultural fields and 1 field with livestock	14 (Alf)	12 (Ca) 13-15 (Co) 17 (Alf) 16 (W) 18 (Sun)	230
C4	5 agricultural fields and 1 area forest	17 (Alf)	16 (W) 18-20 (Sun) 19 (Soy) control (native forest)	210

[1] Ca: cattle, Alf: alfalfa, Co: cotton, Sun: sunflower, Soy: soybean, W: wheat.

(*Geoffroea decorticans* (Gillies ex Hook. & Arn.) Burkart var. *decorticans*), "algarrobo negro" (*Prosopis nigra* (Griseb.) Hieron. var. *nigra*), "algarrobo blanco" (*Prosopis alba* Griseb. var. *alba*) and "jacarandá" (*Jacaranda mimosifolia* D. Don), amongst other native species. The experimental area was surrounded by live tree barriers composed of eucalyptus (*Eucaliptus* sp.), pines (*Pinus* sp.) and "casuarinas" (*Casuarina* sp.).

Samplings

Four seasonal samplings between 2009 and 2010 were carried out. For each field, two linear transects of 100 m in length each were considered, separated from each other by a distance of 100 m, located in the middle part starting from the edge of the field. Spider samplings were obtained by pitfall traps and G-Vac (suction garden-vacuum), to achieve a greater representation of spiders on the soil and canopy plants, respectively. For each transect, 10 pitfall traps were placed separated by 10 m. Traps consisted of plastic containers of 12.2 × 5.2 × 7.5 cm (top diameter × bottom diameter × depth), with saline solution (salt (kg): water (L) in a ratio of 1:8, with drops of detergent), with an activity of seven days. The canopy plant samples were taken randomly with a G-Vac Poulan Pro from a square meter over 1 min, and up to 20 samples were taken for each field. The material collected in each sample was individually preserved in 70% ethyl ethanol and transferred to the laboratory for preparation and subsequent taxonomic determination.

Statistical analysis

For data analysis four different designs (called cases) were considered, each with the same surface area in hectares, as described in Table 1.

Environmental conditions

Heterogeneity of the vertical vegetation structure and heterogeneity of the horizontal structure on the ground for each studied field was considered. To measure heterogeneity of the vertical structure of the vegetation, the VESTA (Vertical Vegetation Structure Analysis) photographic method was performed (Zehm *et al.,* 2003).

Heterogeneity of the vertical vegetation. Vertical digital photographs were taken at random in three areas for each field, using a contrasting panel. Each photograph was bounded in four layers (0-0.50 m, 0.50-1 m, 1-1.50 m and 1.50-2 m). The photographs were analyzed with the program Adobe Photoshop CS5, using the method of different colors (Gilbert & Butt, 2009). The percentage of pixels that represented the variable of study out of the total number of pixels in the photograph, and the value of the variable for each layer was obtained as the average of three areas considered in each field. The value of the "vertical structure" consisted of the average value of the vertical heterogeneity of vegetation taking into account four levels, at each site.

Heterogeneity of the horizontal structure. Three areas of 0.50 × 0.50 m on the ground, where digital photographs were taken randomly from each field, were selected for the horizontal structure. The analysis was similar to that of photographs of the vertical structure, but in this case, three variables were considered: percentage of live vegetation (% VEG), percentage of litter leaf (% COBERT) and percentage of bare soil (% SOIL).

An exploratory analysis of all of the variables using the program SPSS Statistics ver. 17.0 (2008) was performed to determine the existence or absence of autocorrelation between them, using the Spearman's rank correlation coefficient ($p<0.05$).

Table 2. Diversity values obtained in each of the considered cases, within agropastoral systems in the EEA-INTA Reconquista, Santa Fe (Argentina), sorted based on the heterogeneity of the plot design.

	C2	C4	C1	C3
Richness (S)	178	183	142	144
Abundance (N)	5708	4785	3448	4271
Density	5.37	5.98	4.55	4.53
Alfa diversity (mean)	92.30	87.80	79.20	73.60

The vertical and horizontal heterogeneity of each studied design was taken as the mean value of each variable considered in each field, and thus the designs were classified on the basis of environmental heterogeneity. To assign an order of the evaluated designs, an analysis of polar ordination of Bray-Curtis was obtained (McCune & Grace, 2002), using non-autocorrelated variables. The ordering method organized points in reference to the "poles" or endpoints (Bray & Curtis, 1957), using Bray-Curtis distance as a criterion for selection of the method of varianza-regresion (Peck, 2010). The analysis was performed using the program PC-ORD vers. 6 (McCune & Mefford, 2011).

Diversity and density of spiders

For each design, and taking into account the values obtained in the four sampling stations, the following was estimated: species richness (S), abundance of spiders (N), mean alpha diversity (average of the number of species between constituent fields) and density of spiders (average value of the number of individuals collected per sample in each case).

The community of spiders in each design (central versus surroundings) was compared. The average value per sample of alpha spider diversity and density was compared using the Kruskall-Wallis test (KW). All analyses were performed with the program PAST version 2.16 (Hammer *et al.,* 2012).

A multivariate analysis of variance (MANOVA), was obtained using the software Statistics (SPSS) vers. 16.0 to compare the values of species richness and abundance among designs and to check, by multiple comparisons using Tukey's test, whether there were differences between them. Also, we examined the effect of species richness and abundance in each design using ANOVA. Previously, the data were subjected to test normality.

The guilds were classified according to Cardoso *et al.* (2011). Each of the ensembles was compared between the designs through a one-way ANOSIM (similarity analysis), with a permutation of 9999 and a significance level of $p<0.05$, using the PAST program version 2.16 (Hammer *et al.,* 2012).

Results

Heterogeneity of studied designs

The order of the sites, considering the environmental variables, is shown in Figure 2, where C2 (57% agricultural fields and 43% with livestock) was the most heterogeneous while C3 was the least heterogeneous (84% agricultural fields).

Composition of spiders

A total of 14,742 spiders of 29 families, corresponding to 222 species/morphospecies were recorded. The C4 design (agricultural fields with an area of native forest) presented the greatest richness of species (S=183) and C2 (design with greater environmental heterogeneity) recorded the greatest abundance (N=5708). The cases which showed greater heterogeneity in their design reported a higher density of spiders per sample and higher alpha mean diversity (Table 2).

Regarding the composition of spiders, the families Lycosidae, Araneidae, Philodromidae and Oxyopidae were the most abundant in all designs. Ctenidae and Oecobiidae were only found in C3 and C4, and Oonopidae, Sparassidae and Actinopodidae were only found in C4. Zodariidae was not found in C1, and Micropholcommatidae was not found in C3 (Table 3). Regarding the richness of species, and considering the heterogeneity of the analyzed designs, the families Salticidae, Araneidae, Linyphiidae and

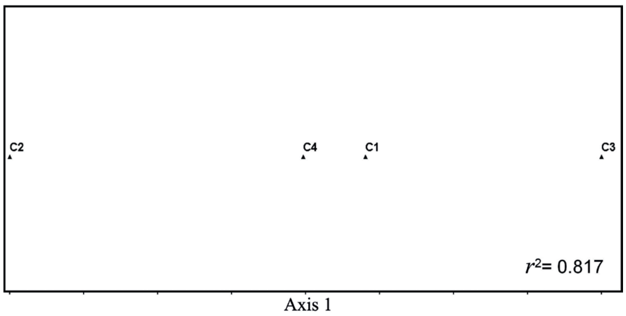

Figure 2. Polar ordering of Bray-Curtis for the studied cases with regard to the heterogeneity of soil and vegetation variables in agropastoral systems in the EEA-INTA Reconquista, Santa Fe (Argentina).

Table 3. Richness and total abundance per family and abundance of guilds in each case, within agropastoral systems in the EEA-INTA Reconquista, Santa Fe (Argentina). (S: richness of species, N: abundance; NG: abundance of guilds).

	C2			C4			C1			C3		
	S	**N**	**NG**	**S**	**N**	**NG**	**S**	**N**	**NG**	**S**	**N**	**NG**
Ambush hunters			**218**			**320**			**277**			**403**
Thomisidae	15	218		17	320		13	277		13	403	
Ground hunters			**794**			**1043**			**720**			**999**
Lycosidae	18	648		18	961		17	670		18	933	
Gnaphosidae	14	103		11	41		8	21		6	31	
Oonopidae	0	0		1	1		0	0		0	0	
Corinnidae	7	39		8	39		5	28		3	32	
Prodidomidae	1	4		1	1		1	1		1	3	
Orb web weavers			**2022**			**1054**			**842**			**1010**
Araneidae	23	1753		24	757		21	663		20	831	
Nephilidae	2	12		2	17		2	7		2	15	
Tetragnathidae	3	255		3	277		2	171		3	161	
Theridiosomatidae	1	2		1	3		1	1		1	3	
Other hunters			**2018**			**1730**			**1000**			**1316**
Anyphaenidae	8	94		9	161		4	31		4	36	
Clubionidae	1	1		5	13		1	1		2	4	
Ctenidae	0	0		1	2		0	0		1	1	
Miturgidae	3	105		6	94		5	77		4	63	
Oxyopidae	1	325		1	632		1	268		1	528	
Philodromidae	4	1017		4	594		4	491		4	497	
Salticidae	36	475		30	228		24	132		24	186	
Scytodidae	1	1		2	5		0	0		1	1	
Sparassidae	0	0		1	1		0	0		0	0	
Sensing web weavers			**0**			**2**			**0**			**1**
Actinopodidae	0	0		1	1		0	0		0	0	
Oecobiidae	0	0		1	1		0	0		1	1	
Sheet web weavers			**371**			**366**			**335**			**293**
Hahniidae	1	14		1	10		1	14		1	6	
Pisauridae	1	55		1	59		1	128		1	62	
Linyphiidae	21	302		19	297		16	193		17	225	
Space web weavers			**277**			**265**			**274**			**248**
Dictynidae	2	33		2	16		2	26		2	13	
Micropholcommatidae	1	2		1	2		1	3		0	0	
Titanoecidae	1	7		1	25		1	88		1	9	
Theridiidae	12	235		10	222		11	157		12	226	
Specialists			**8**			**5**			**0**			**1**
Zodariidae	1	8		1	5		0	0		1	1	
Total	**178**	**5708**	**5708**	**183**	**4785**	**4785**	**142**	**3448**	**3448**	**144**	**4271**	**4271**

Table 4. Comparison of averages (mean difference) of species richness (S) and abundance (N) of spiders for each of the cases. *p*-values<0.05 are significantly different, as determined by Tukey's test.

Dependent variable	Comparison (case *vs* case)		Median difference	*p*
S	C1	C2	13.1	0.041
		C3	5.6	0.600
		C4	8.6	0.277
	C2	C3	18.7	0.001
		C4	4.5	0.725
	C3	C4	14.3	0.017
N	C1	C2	125.8	0.708
		C3	79.5	0.904
		C4	107.9	0.809
	C2	C3	205.3	0.254
		C4	17.9	0.998
	C3	C4	187.4	0.360

Lycosidae contributed to the greatest number of species.

The MANOVA analysis showed statistically significant differences between abundance and species richness (MANOVA: Wilk´s lambda=0.331, F=4.190, p=0.003). Table 4 compares the averages (mean difference) of species richness and abundance of spiders for each of the cases, where richness of species showed statistically significant differences (ANOVA: F=9.053, df=3, p=0.001) between C1-C2, C2-C3 and C3-C4, while abundance of spiders was similar among the tested cases with no statistical differences (ANOVA: F=2.174, df=3, p=0.126).

Statistically significant differences were obtained when we compared the mean value of alpha diversity per sample of spiders and the mean density per sample between the central and surrounding fields within each design (KW: H=194.6, p=0.001; H=92.29, p=0.001, respectively) (Fig. 3). In the designs C2, C3 and C4, the alpha diversity of spiders in the surrounding fields showed a higher average than in the central field, with the highest for C4 (Fig. 3a). Otherwise, the mean density obtained was higher in the central field compared to the surrounding ones, except for C3 (Fig. 3b).

Composition of guilds

Eight guilds were registered. All of the guilds were present in C3 and C4, while the "Sensing web weavers" were not recorded in C1 and C2, and the "Specialists"

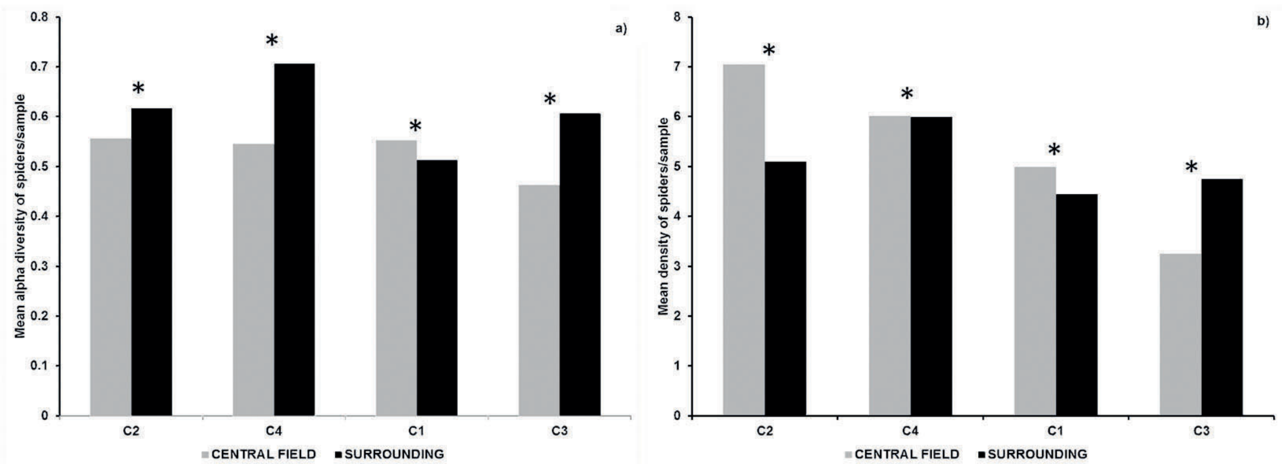

Figure 3. Comparison of mean alpha diversity (a) and mean density of spiders (b) per sample in the central field and surrounding fields for the considered agropastoral systems in the EEA-INTA Reconquista, Santa Fe (Argentina). *Asterisks indicate statistical differences between means, p<0.05.

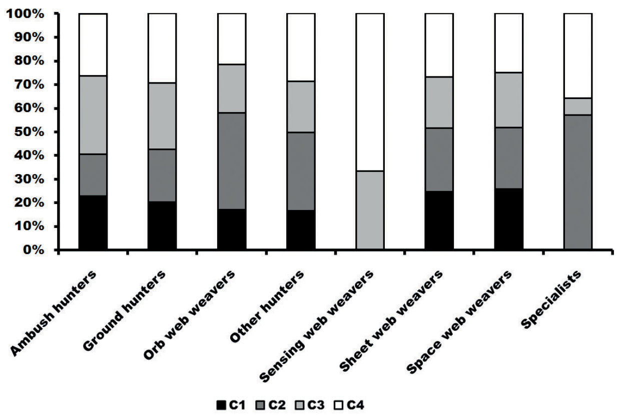

Figure 4. Proportion of guilds by case, within agropastoral systems in the EEA-INTA Reconquista, Santa Fe (Argentina).

were not found in C1 (Fig. 4). "Ground hunters", "Other hunters" and "Orb web weavers" were the most abundant in all cases (Table 3).

The ANOSIM results showed statistically significant differences between the assemblies of spiders, demonstrating how heterogeneity of each of the designs was manifested in all guilds.

The "Ambush hunters" showed statistically significant differences between C1-C2 and C2-C3 (ANOSIM: R=0.29, p=0.025; R=0.41, p=0.006, respectively) and "Other hunters" in C2-C3 (ANOSIM: R=0.22, p=0.028). The "Orb web weavers" showed differences between C2-C3 and C2-C4 (ANOSIM: R=0.30, p=0.025; R=0.29, p=0.031 respectively). The rest of the guilds (Specialists, Ground hunters, Sensing web weavers, Sheet web weavers and Space web weavers) did not significantly change their assemblies for the studied cases.

Discussion

This is the first study in Argentina on the diversity of spiders in agropastoral systems. This study evaluated the effects of different designs of agricultural fields with or without livestock and forested areas on the maintenance of a dominant predatory group, with the goal of improving regulation of pest species. These experiences are the first trials that could be replicated to other scales, as well with other combinations of fields into new designs. These could permit us to test which one would affect in a positive manner the sustainability of current production systems. The results showed that the communities of spiders in the North of Santa Fe are affected by the design of fields within agropastoral systems. The araneofauna registered in the studied area represents 43% of the total number of families cited in Argentina (World Spider Catalog, 2016), and the richness of collected species exceeds the values known to the province of Santa Fe in soybean crops (Beltramo *et al.,* 2006) and cotton (Almada *et al.,* 2012) and to that of other regions or other crops studied in the country (Liljesthröm *et al.,* 2002; Armendano & González, 2009; 2011; Benamú Pino, 2010).

From the recollected families of this study, four of them were the most common in all cases (Araneidae, Lycosidae, Oxyopidae and Philodromidae), while Araneidae, Linyphiidae, Lycosidae and Salticidae contributed to the greatest number of species in the systems studied. These families coincided partially with those recorded in crops of soybeans, alfalfa, wheat and cotton (Liljesthröm *et al.,* 2002; Beltramo *et al.,* 2006; Armendano & González, 2009, 2011; Almada *et al.,* 2012, respectively), where Anyphaenidae, Salticidae and Linyphiidae were the main families in terms of their abundance. These families are also represented with greater abundance in livestock systems (Toti *et al.,* 2000; Warui *et al.,* 2005), as well as in reserves and national parks (Corronca & Abdala, 1994; Rubio *et al.,* 2004; Grismado, 2007; Avalos *et al.,* 2009; Rubio, 2015).

The production system designs with a greater number of fields with livestock and an equal area for agriculture were the most heterogeneous, followed by designs with agricultural fields with an area of native forest. In these cases, the spider communities were more diverse than in the designs that were environmentally less heterogeneous (C1 and C3). A positive relationship between improved community attributes and an increase in habitat heterogeneity was found as proposed by various authors (Sunderland & Samu, 2000; Díaz Porres *et al.,* 2014; Dennis *et al.,* 2015).

Our results did not coincide with those of Dennis *et al.* (2015), Warui *et al.* (2005) and Bromham *et al.* (1999) who mentioned that the presence of large herbivores (especially livestock during grazing) affects spiders indirectly through the reduction of vegetation cover, generating changes in the structure of the vegetation/architecture of particular plant species and increasing the abundance of pest species. We found that bigger grazing areas within the design translated into a greater mean alpha diversity and density of spiders in the community. This would possibly have a better impact on the phytophagous species that are part of the spiders' diet in these production systems. The increased heterogeneity in C2 with a larger livestock area was an environment where disturbance from grazing increased the heterogeneity of the vegetation throughout the year of study, leading to a higher density and diversity of spiders.

The designs with only cultivated fields directly affected the mean alpha diversity and density of spiders as did those designs having a single field with livestock. Disturbances from cultivated systems (such as tilling practices) with low heterogeneity from a single area with livestock reduced density and diversity as demonstrated in C3.

On the other hand, the incorporation of an area of native forest within designs allowed for a greater diversity of habitat to be exploited by spiders, as it provided a greater availability of potential niches for the beneficial fauna, as observed in C4. This is comparable to results from Foelix (1982), who noted that the distribution and population density of spiders in a habitat is related to the type of vegetation. This also supports the "habitat heterogeneity hypothesis", where structurally complex habitats may offer more niches and diverse ways to exploit environmental resources, and thus increase the diversity of species (Bazzaz, 1975; Uetz, 1991; Altieri, 1999).

In most cases, the central fields presented a higher density of spiders than their respective surroundings. This should be considered when planning agropastoral systems where the goal is to increase natural enemies of insects to control pests in specific crops, since a higher number of predatory individuals would ensure an effective biological control and thus contribute to agricultural productivity (Tscharntke *et al.,* 2008).

Nevertheless, the mean alpha diversity was higher in the surrounding fields than in the central ones. The surrounding fields might be areas of refuge and maintenance of spiders in different stages of the crop, as well as areas for the recolonization of spiders when the crop is affected by different disturbances like tillage practices (such as applications of agrochemicals) (New, 2005). However, there is a group of typical and specialist spiders for each environment and agrobiont species that dominate and are specific to each crop (Luczak, 1979; Samu & Szinetár, 2002). Maybe this was the case for the Actinopodidae and Sparassidae families (uncommon into agroecosystems), who, although low in number, were found only in C4 (including the natural environment in the design).

The different proportions of guilds reported for each case corresponds to those proposed by Uetz *et al.* (1999), who established that structural complexity determines the composition of a growing guild and indirectly influences pests. The high proportion of the guilds "Ground hunters", "Other hunters" and "Orb web weavers", and the differences reported between cases of different heterogeneities (C2-C3, C1-C2 and C2-C4), can be directly related to the composition and complexity of the landscape (Roschewitz *et al.,* 2005; Schmidt *et al*., 2008). More heterogeneous designs offer greater plant diversity, increasing the variety of ecological niches for the establishment of different guilds (Weyland & Zaccagnini, 2008).

The absence of the guilds "Specialists" and "Sensing web weavers" in purely agricultural environments (C1) demonstrates that the simplification of the vertical and horizontal structure favors certain species. In this way we can support the last hypothesis, where the composition of guilds is different in agropastoral environments compared to those that are agricultural. However, in C2 the "Sensing web weavers" were not found as their families are only found in natural environments, indicating once again that the incorporation of natural areas and fields with pastures will generate heterogeneous environments suitable for the establishment of different groups of spiders (Cardoso *et al.*, 2011; García *et al.,* 2011).

To achieve self-regulation of the system and to improve the impact of natural enemies of pest species, it is essential to plan sustainable designs considering the elements from the environment. Our results show that those designs that integrate agricultural fields with livestock (with similar surface areas for crops and cattle), or areas of forests within an agropastoral landscape, offer heterogeneous, complex habitats in favor of a better assembly of spiders. The areas around the crops that contain windbreakers, fences or belts of protection ensure the maintenance of general biodiversity, and of the araneofauna in particular, for the sustainability of the entire productive system.

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